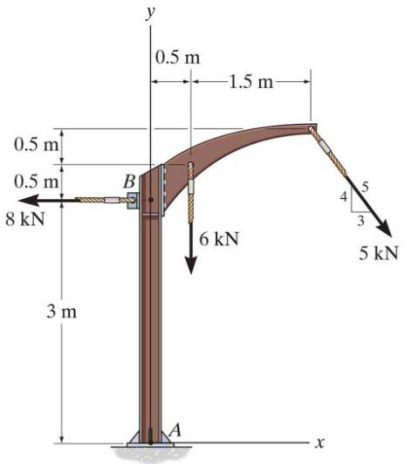
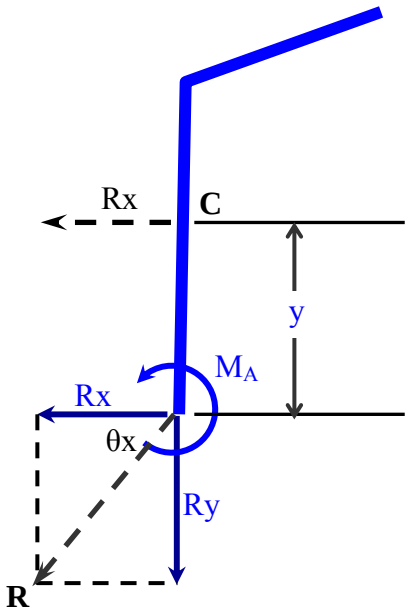
Problem 1 (15 Marks) F 4.34 (p 178)

For the system shown, determine

(a) The rectangular components of the resultant force, R.
(b) The magnitude of the resultant force, R.
(c) The orientation, θ_X, of the resultant force, with respect to the horizontal axis.
(d) The intersection, y, of the line of action of the resultant with the y-axis





Force Resultant at A

$$\vec{R} = \sum \vec{F} = \sum F_x \vec{i} + \sum F_y \vec{j}$$

$$R_x = \sum F_x = -8 + \left(\tfrac{3}{5}\right)5 = -\mathbf{5\,kN} \triangleleft \ \textbf{(a)}$$

$$R_y = \sum F_y = -6 - \left(\tfrac{4}{5}\right)5 = -\mathbf{10\,kN} \triangleleft \ \textbf{(a)}$$

$$\mathbf{R} = \sqrt{(R_x)^2 + (R_y)^2} = \sqrt{(-5)^2 + (-10)^2} = \mathbf{11.2\,kN} \triangleleft \ \textbf{(b)}$$

$$\theta_x = \tan^{-1}\left(\frac{R_y}{R_x}\right) = \tan^{-1}\left(\frac{-10}{-5}\right) = 63.4^o \ \triangleleft \textbf{(c)}$$

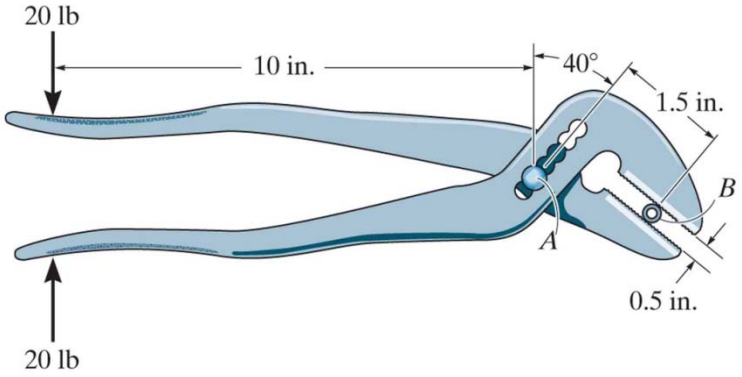
Moment Resultant at A

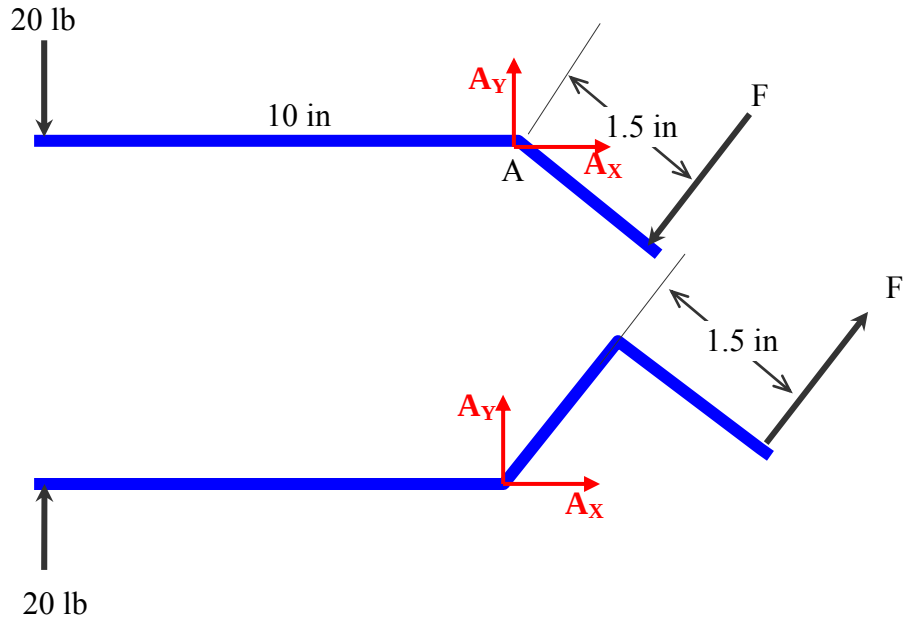
$$\mathbf{M_A} = 8(3) - 6(0.5) - \left(\tfrac{3}{5}\right)5(3 + 0.5 + 0.5) - \left(\tfrac{4}{5}\right)5(0.5 + 1.5)$$

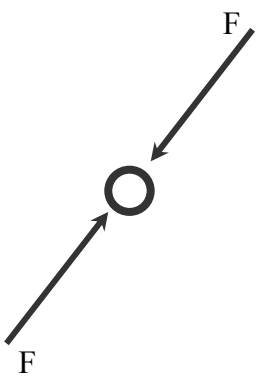
$$\mathbf{M_A} = 24 - 3 - 12 - 8 = 1\,\mathbf{kN.m}$$

$$\mathbf{M_A} = \mathbf{R_x} y \ \Rightarrow \ y = \frac{\mathbf{M_A}}{\mathbf{R_x}} = \frac{1}{5} = 0.200\ \mathbf{m}$$

Problem 2 (10 Marks) 6.127 (p326)
Determine the clamping force exerted on the smooth pipe at B if a force of 20 lb is applied to the handles of the pliers. The pliers are pinned at A.







$\Sigma M_A = 0$

$20(10) - F(1.5) = 0$

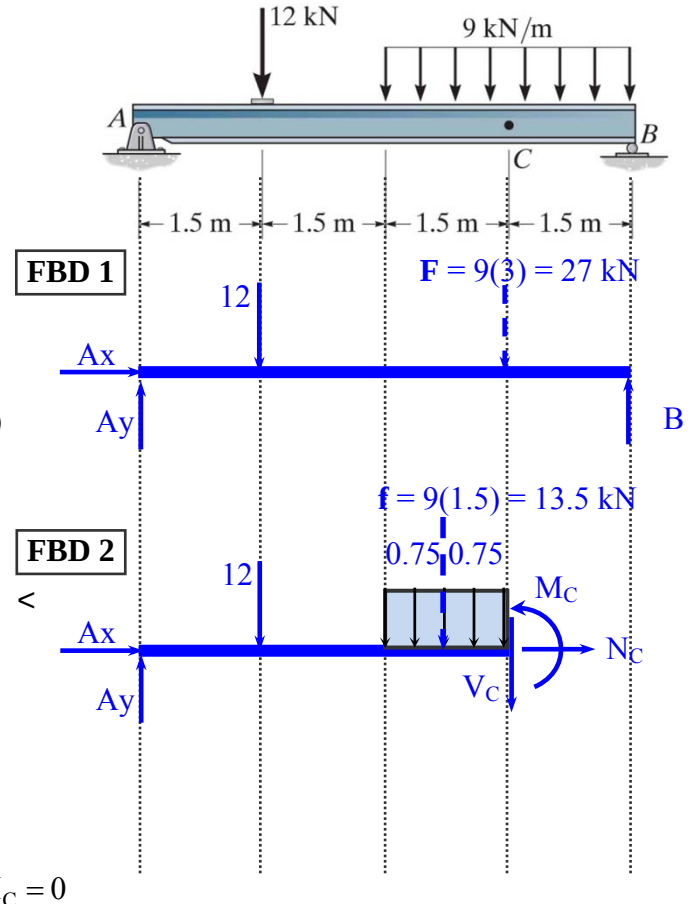
$F = \frac{200}{1.5} = 133 \text{ lb}$ <

Problem 3 (15 Marks) F 7.4 (p337)
For the beam shown, determine:

(a) Reactions at A and B

(b) Internal forces at point C

- Axial Force, N_C
- Shear Force, V_C
- Bending Moment, N_C



(a) Reactions. From FBD 1

$\Sigma Fx = 0 \rightarrow \quad Ax = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$

$\Sigma Fy = 0 \rightarrow \quad Ay - 12 - F + B = 0 \ldots\ldots\ldots\ldots\ldots\ldots (2)$

$\Sigma M_B = 0 \rightarrow \quad -Ay(6) + 12(4.5) + 27(4.5) = 0 \ldots\ldots (3)$

From (3) $\quad Ay = \dfrac{94.5}{6} = 15.75 = 15.8 \text{ kN} \quad <$

From (2) $\quad B = 27 + 12 - 15.75 = 23.25 = 25.3 \text{ kN} \quad <$

(b) Internal forces at C. From FBD 2

$\Sigma Fx = 0 \rightarrow \quad N_C = 0 \quad <$

$\Sigma Fy = 0 \rightarrow \quad 15.75 - 12 - 13.5 - V_C = 0$

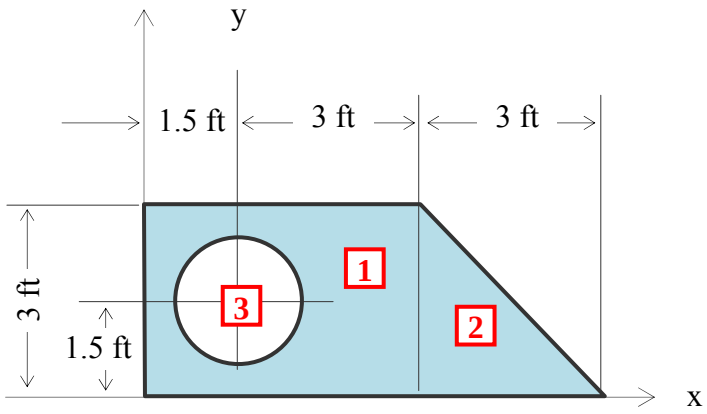
$V_C = -9.75 = 9.8 \text{ kN} \uparrow\downarrow \quad <$

$\Sigma M_C = 0 \rightarrow \quad -15.75(4.5) + 12(3) + 13.5(0.75) + M_C = 0$

$M_C = +24.75 = 24.8 \text{ kN.m} \cup \quad <$

Problem 4 (20 Marks) 9.60 (p 479)

A 2 ft diameter hole is punched out of the trapezoidal plate shown. Locate the coordinates $\bar{x}$ and $\bar{y}$ for the centre of gravity of this composite.



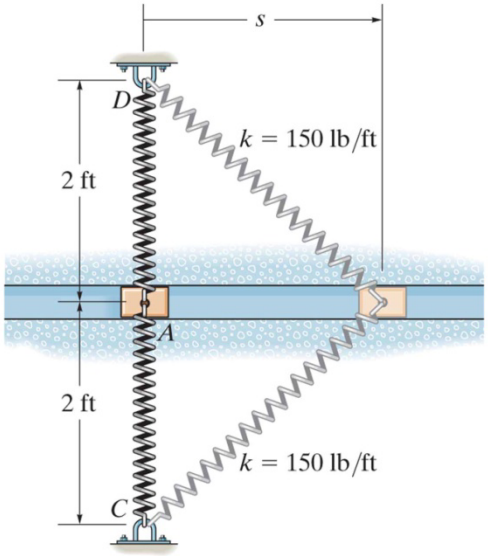
Part	$\mathbf{A_i}$	$\mathbf{x_i}$	$\mathbf{y_i}$	$\mathbf{A_i x_i}$	$\mathbf{A_i y_i}$
Rectangle - 1	13.5	2.25	1.5	30.375	20.25
Triangle - 2	4.5	5.5	1	24.75	4.5
Circle - 3	-3.14	1.5	1.5	-4.712	-4.712
$\sum$	14.858			50.413	20.038

Centre of gravity

$$\bar{x} = \frac{\sum A_i x_i}{\sum A_i} = \frac{50.413}{14.858} = 3.39\ ft$$

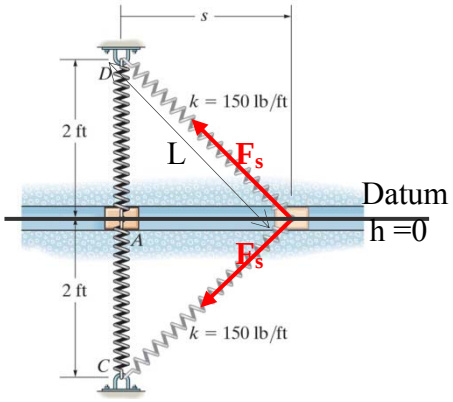
$$\bar{y} = \frac{\sum A_i y_i}{\sum A_i} = \frac{20.038}{14.858} = 1.35\ ft$$

Problem 5 (20 Marks) 14.79 (p 211)
Block A has a weight of 1.5 lb and slides in the smooth horizontal slot. If the block is drawn back to s = 1.5 ft and released from rest, determine its speed at the instant s = 0. Each of the two springs has a stiffness of k = 150 lb/ft and an unstretched length of 0.5 ft.



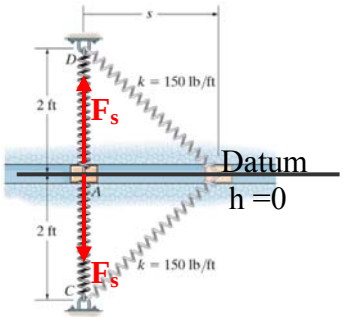
Use equation of **Conservation of Energy**
$E_1 = T_1 + V_1 = T_2 + V_2 = E_2$

When the block is stretched to s = 1.5 ft, (state 1)



$$E_1 = T_1 + V_1 = \frac{1}{2}mV_1^2 + mgh + 2 \times \frac{1}{2}k(\Delta s_1)^2$$
$L = \sqrt{1.5^2 + 2^2} = 2.5\ ft$
$\Delta s_1 = 2.5 - 0.5 = 2.0\ ft$
h = 0 ft
V_1 = 0 ft/s -- starts from rest
$$E_1 = \frac{1}{2}mV_1^2 + mgh + 2 \times \frac{1}{2}k(\Delta s_1)^2 = 0 + 0 + 2 \times \frac{1}{2} \times 150 \times 2^2 = 600\ lb.ft$$

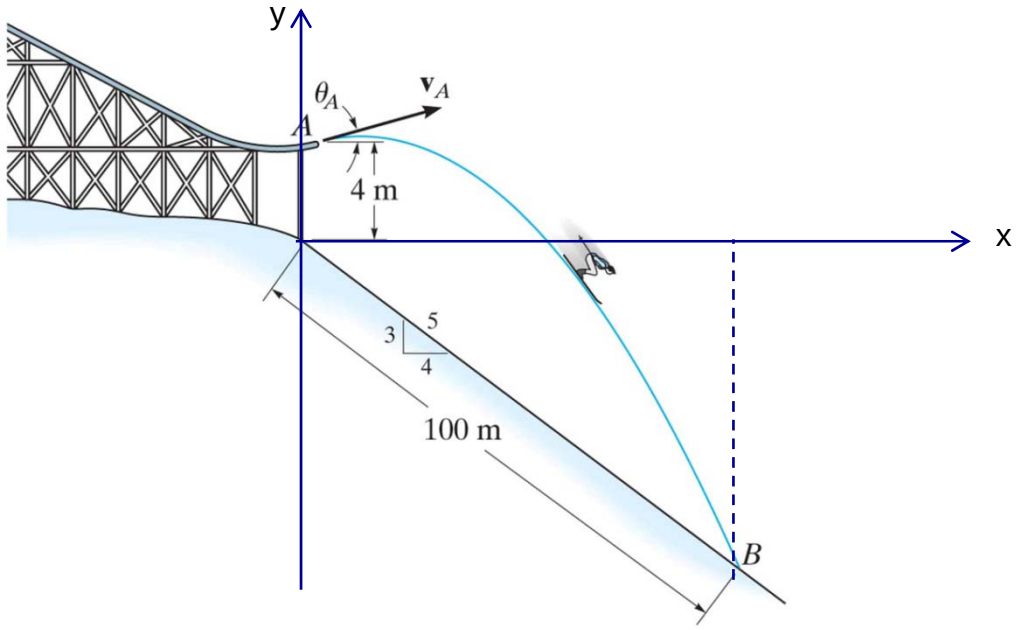
When the block is at 2 = 0 m (state 2)
$$E_2 = T_2 + V_2 = \frac{1}{2}mV_2^2 + mgh + 2 \times \frac{1}{2}k(\Delta s_2)^2$$
$\Delta s_2 = 2.0 - 0.5 = 1.5\ ft$
h = 0 ft
$$E_2 = \frac{1}{2}mV_2^2 + mgh + 2 \times \frac{1}{2}k(\Delta s_2)^2 = \frac{1}{2} \times \frac{1.5}{32.2}V_2^2 + 0 + 2 \times \frac{1}{2} \times 150 \times 1.5^2$$



$E_1 = E_2 \Rightarrow 600 = 0.0233V_2^2 + 337.5$

V_2 = 106 ft/s

Problem 6 (20 Marks) 12.110 (p 52)
The skier leaves the ramp A at an angle $\theta_A = 25^o$ with the horizontal. If she strikes the ground at B, determine her initial speed v_A and the time of flight t_{AB}.



$V_{Ax} = V_A\cos 25^o = 0.906V_A$
$V_{Ay} = V_A\sin 25^o = 0.423V_A$

$$x_B = \frac{4}{5} \times 100 = 80\ m$$
$$y_B = -\frac{3}{5} \times 100 = -60\ m$$

Horizontal Motion
$a_x = 0$
$$x_B = x_A + V_{Ax}t \Rightarrow t = \frac{80}{0.906V_A}$$

Vertical Motion
$a_y = -g = -9.81$ m/s
$$y_B = y_A + V_{Ay}t - \frac{1}{2}9.81t^2$$
$$-60 = 4 + 0.423V_A\left(\frac{80}{0.906V_A}\right) - \frac{1}{2}9.81\left(\frac{80}{0.906V_A}\right)^2$$
$V_A = 19.4$ m/s

$$t = \frac{80}{0.906 \times 19.4} = 4.55\ s$$